Name _____ Date _____ Class _____

LAB 17.1 LABORATORY MANUAL

The Rate of a Reaction

Use with Section 17.2

A chemical equation shows that as a chemical reaction takes place, reactants are changed into products. The reaction rate of a chemical reaction is often expressed as the change in concentration of a reactant or a product in a unit amount of time. In this activity, the reaction rate will be calculated from the amount of time it takes for a given amount of magnesium (Mg) to react completely with hydrochloric acid (HCl).

Problem

What is the relationship between temperature and reaction rate? What is the relationship between concentration and reaction rate?

Objectives

- **Measure** the amount of time it takes for a uniform strip of Mg ribbon to react completely with HCl under varying conditions.
- **Graph** the data.
- **Infer** the relationships between reaction rates and varied temperatures and concentrations.

Materials

magnesium ribbon
sandpaper
1*M* hydrochloric acid (HCl)
3*M* hydrochloric acid (HCl)
ice
test tubes (8)
250-mL beakers (4)
10-mL graduated cylinder
thermometer
stirring rod
Bunsen burner
clock or timer
ruler
scissors
ring stand
iron ring
wire gauze

Safety Precautions

- **Always wear safety goggles, a lab apron, and gloves.**
- **Hot objects may not appear to be hot.**
- **Hydrochloric acid is toxic, corrosive to skin, and reacts with metals.**
- **Open flames may ignite hair or loose clothing.**

Pre-Lab

1. Define *reaction rate*.
2. Write the mathematical equation used to determine the average rate of a chemical reaction. What factor is held constant? What are the variables?
3. Read the entire laboratory activity. Form a hypothesis about how an increase in temperature will affect reaction rate. Form a second hypothesis about how an increase in concentration will affect reaction rate. Record your hypotheses on page 130.
4. Summarize the procedures you will follow to test your hypotheses.

Procedure

Clean a 30-cm strip of magnesium ribbon with sandpaper. Cut the ribbon into 3.0-cm pieces.

Part A: Effect of Temperature

1. Pour 10 mL of 1.0*M* hydrochloric acid into a clean, dry test tube.
2. Place the test tube in a 250-mL beaker that contains 150 mL of ice water.
3. Wait 3 min. Measure the temperature of the acid and record it in the **Part A Data Table.**
4. Remove the thermometer from the acid and place a piece of magnesium ribbon into the acid. Use

the stirring rod to keep the magnesium completely submerged throughout the reaction.

5. Starting as soon as the magnesium is in contact with the acid, measure the time required for the magnesium to react completely. Record the reaction time.
6. Measure and record the temperature of the acid after the reaction.
7. Set up a hot-water bath and repeat the experiment at temperatures of about 25°C, 50°C, and 100°C.

Part B: Effect of Concentration

1. Pour 10 mL of 3.0*M* hydrochloric acid into a clean, dry test tube.
2. Place the test tube in a 250-mL beaker that contains 150 mL of tap water.
3. Wait 3 min, then place a piece of magnesium ribbon into the acid. Use the stirring rod to keep the magnesium completely submerged throughout the reaction.
4. Starting as soon as the magnesium is in contact with the acid, measure the time required for the magnesium to react completely. Record the reaction time in the **Part B Data Table**.
5. Prepare the following solutions and pour each into a separate, clean, dry test tube: 4.0 mL of tap water and 6.0 mL of 3.0*M* HCl; 7.0 mL of tap water and 3.0 mL of 3.0*M* HCl; 9.0 mL of tap water and 1.0 mL of 3.0*M* HCl.
6. Place each test tube in a 250-mL beaker that contains 150 mL of tap water.
7. Repeat steps 3 and 4 for each test tube.

Hypotheses

_____

_____

_____

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Cleanup and Disposal

1. Be sure the gas supply for the Bunsen burner is turned off.
2. Dispose of materials as directed by your teacher.
3. Return all lab equipment to its proper place. Report any broken or damaged equipment.
4. Wash your hands thoroughly before leaving the lab.

Data and Observations

Part A Data Table

Tube	Initial temperature (°C)	Final temperature (°C)	Average temperature (°C)	Reaction time (s)	Rate of reaction
1					
2					
3					
4					

Part B Data Table			
Tube	**Acid**	**Reaction time (s)**	**Rate of reaction**
1	10 mL 3.0*M* HCl, 0.0 mL water		
2	6.0 mL 3.0*M* HCl, 4.0 mL water		
3	3.0 mL 3.0*M* HCl, 7.0 mL water		
4	1.0 mL 3.0*M* HCl, 9.0 mL water		

1. Why is it necessary to clean the magnesium?

2. Why are the volume and molarity of the acid the same in each trial of Part A?

3. What effect does temperature have on reaction rate?

4. Why are the trials in Part B carried out in a beaker of water?

5. What effect does concentration have on reaction rate?

Analyze and Conclude

1. Using Numbers Because the mass of magnesium is the same in each reaction, assume the change in quantity to be 1. Thus, the rate of reaction is calculated by dividing 1 by the reaction time. Calculate and record in the data tables the average temperature and the rate of reaction for each tube in Part A and the rate of reaction for each tube in Part B. Why was an average temperature used in Part A?

2. **Observing and Inferring** Did the reaction rate decrease, increase, or remain the same as the temperature of the acid solution increased? As the temperature of the acid solution decreased? Explain whether the reaction rates are directly proportional or inversely proportional to temperature.

3. **Graphing Data** On a sheet of graph paper, make a graph of temperature versus time, using the data from Part A. Then make a graph of concentration versus time, using the data from Part B. Were your hypotheses supported? Explain.

4. **Making a Prediction** Would you expect the reaction rate in Part A to increase if the acid was more concentrated? Explain why.

5. **Making a Prediction** Would you expect the graphs to have the same shapes if each magnesium strip was 6.0 cm long instead of 3.0 cm long?

6. **Error Analysis** What could you have done to improve the precision of the measurements?

Real-World Chemistry

1. What effect does acid rain have on the rate of corrosion of metals used in buildings, automobiles, and statues? How can concentration of the acid in the rain, and thus the rate of corrosion, be controlled?
2. Explain why refrigerated or frozen foods do not spoil as quickly as those left at room temperature.
3. For centuries, the production and destruction of ozone in Earth's ozone layer was constant. Explain why in recent decades the ozone has been depleted faster than it was replaced.